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<p>(54) Title: COMPOSITIONS AND METHODS FOR ACTIVE VACCINATION</p> <p>(57) Abstract</p> <p>Non-Hodgkin's lymphoma (NHL) is treated, not by administration of an anti-CD20 monoclonal antibody, but by the administration of CD20 itself, or an immunogenic fragment of the extracellular portion thereof, coupled to or administered with an antigenic carrier moiety such as keyhole limpet hemocyanin (KLH). This results in the stimulation of the production of polyclonal antibodies against CD20 (or an immunogenic fragment thereof) which has the effect of reducing the number of B-cells, including malignant B-cells, and thus provides an active vaccine. The same approach can be used for therapeutics for other diseases and conditions in which target cells possess a transmembrane protein, and is particularly applicable to those diseases and conditions for which administration of antibodies to transmembrane proteins or peptides (i.e., passive therapy) have been shown to provide therapeutic benefits, and especially in the situations where the target is also capable of transducing or receiving a signal important for cell growth or function. This would include, for example, Her2/neu, VEGF receptor, epidermal growth factor receptor, the CD19 molecule, interleukin-2-receptor, interleukin-4-receptor, and the P-glycoprotein, also known as the multidrug-resistance protein.</p>		

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COMPOSITIONS AND METHODS FOR ACTIVE VACCINATION

BACKGROUND OF THE INVENTION

This application relates to an active vaccine approach to the treatment of cancer and other diseases. The approach is applicable to a number of cancers and diseases, although a preferred embodiment provides an active vaccine for treatment of B cell Non-
5 Hodgkin's Lymphoma (NHL).

NHL is characterized by a clonal proliferation of malignant B cells. The treatment of NHL across a broad spectrum of patients remains a challenge, although numerous therapeutic approaches have been proposed and tried.

The most common therapeutic approach being used today is chemotherapy.
10 While chemotherapy is effective for some period of time in most patients, a significant percentage of patients are not cured and experience a relapse.

Treatments have been proposed based on anti-idiotypic therapy. In anti-idiotypic therapy, a cell surface molecule which is expressed by malignant cells but not by normal cells is used to create patient-specific antibodies which are then administered to the
15 patient. See, Miller, et al., *New Engl. J. Med.* 306: 517-522 (1982). Autologous patient-derived idiotype proteins have also been conjugated with keyhole limpet hemocyanin to produce a vaccine which has demonstrated efficacy and can elicit B and T cell immune responses. Kwak et al., *New Engl. J. Med.* 327: 1209-1215 (1992). Hybridoma-derived idiotype was co-cultured with patient-derived dendritic cells which acted as antigen
20 presenters upon re-infusion into the patient and showed clinical efficacy. Hsu et al., *Nature Medicine* 2: 52-58 (1996). Idiotypic vaccines made in lipid-based carriers are disclosed in International Patent Publication WO98/14170.

Treatments have also been proposed using antibodies directed to CD20, a transmembrane protein that is expressed by both normal and malignant B-cells during parts of
25 the B cell development cycle. Using single-dose infusions with anti-CD20 monoclonal antibodies, partial or minor tumor regressions were observed in 6 of 15 patients in a Phase I clinical study. Maloney et al., *Blood* 84: 2457-2466 (1994). In Phase II studies, 17 of 37 patients showed complete or partial remissions. In December 1997, the FDA approved the

first antibody-based therapy for NHL. Rituximab (Ritvaxan, IDEC/Genentech) is a chimeric human/murine antibody approved for the treatment of patients with relapsed or refractory low-grade or follicular CD20⁺ B cell NHL. Maloney et al., *Blood* 90: 2188-2195 (1997).

Combinations of chemotherapy and anti-CD20 therapy have been reported as having better therapeutic efficacy, with 11 of 11 patients showing complete or partial remission. Czuczman et al., Abstract 53, *Ann. Oncol.* 7, Supp. 1: 56 (1996).

While therapeutic regimens using anti-CD20 concepts are potentially effective, all of these therapies have the drawback of being passive therapies, i.e., they do not directly involve the immune system of the patient. Thus, these therapies may require the continued administration of the therapeutic agent for efficacy and do not provide any long-term protection against recurrence. In addition, the passive therapy is monoclonal in nature, therefore escape is possible. It would therefore be desirable to have an active therapy, that is a therapeutic agent which when administered to the patient stimulates an immune response against CD20 found in B-cells.

It is an object of the present invention to provide such a therapy. It is a further object of the invention to provide an active polyclonal therapy that is difficult to evade.

SUMMARY OF THE INVENTION

In accordance with the present invention, NHL is treated, not by administration of an anti-CD20 monoclonal antibody, but by the administration of CD20 itself, or an immunogenic fragment of the extracellular portion thereof, coupled to or administered with an antigenic carrier moiety such as keyhole limpet hemocyanin (KLH). This results in the stimulation of the production of polyclonal antibodies against CD20 (or an immunogenic fragment thereof) which has the affect of reducing the number of B-cells, including malignant B-cells. Thus, the invention provides an active vaccine. The same approach can be used for therapeutics for other diseases and conditions in which target cells possess a transmembrane protein, and is particularly applicable to those diseases and conditions for which administration of antibodies to transmembrane proteins or peptides (i.e., passive therapy) have been shown to provide therapeutic benefits, and especially in the

situations where the target is also capable of transducing or receiving a signal important for cell growth or function. This would include, for example, Her2/neu, VEGF receptor, epidermal growth factor receptor, the CD19 molecule, interleukin-2-receptor, interleukin-4-receptor, and the P-glycoprotein, also known as the multidrug-resistance protein.

5

BRIEF DESCRIPTION OF THE FIGURES

Figs. 1A and B show ELISA results for formation of antibodies to human and mouse CD20 in vaccinated mice;

10 Figs. 2A and B shows results for binding of control B1 antibodies or antibodies in plasma from a mouse treated with human CD20-KLH conjugate with Raji B NHL cells;

Fig. 3 shows CP19⁺ B cell levels in mice treated with human or mouse CD20-KLH conjugate;

Fig. 4 shows the domain structure of human Her2;

15 Fig. 5 shows the domain structure of human EGFR;

Figs. 6A-D shows the cross-reactivity of antibodies generated in response to human or mouse CD20 fragments;

Figs. 7A-D show the importance of carrier protein and adjuvant in generating an immune response;

20 Figs. 8A-D shows the immune response generated using different adjuvants; and

Figs. 9A-I shows CP19⁺ B cell levels in mice treated with human or mouse CD20-KLH conjugate.

25

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides an active vaccine therapy which can be used in the treatment of a variety of cancers and related conditions in which it is desirable to bring about the death of a target group of cells. Conventionally, immunotherapies targeting cells have sought to obtain a cellular immune response (T-cells that recognize the target cells), since a humoral immune response (antibodies that recognize the target cells) alone is not

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deemed sufficient to achieve the desired result of cell death. The present invention departs from this conventional wisdom, and effectively utilizes a humoral immune response against the target cells to provide therapeutic benefit. The targets for therapy include cell surface proteins that when bound by a ligand signal to the cell. The vaccine induced antibody response will mimic ligand binding and cause similar signaling events which can imitate the process of programmed cell death (apoptosis) or halt the cell from growing or change the cancer cell's sensitivity to chemotherapy.

By way of example, the invention is suitably employed in the treatment of NHL and other B cell diseases such as chronic lymphocytic leukemia, auto-immune disorders and B-cell regulatory disorders. In accordance with this embodiment of the invention, a peptide antigen is prepared which contains at least an immunogenic portion of the extracellular domain of CD20 coupled to or administered with an antigenic carrier protein. The CD20 component of the peptide antigen may be syngeneic or it may be xenogeneic. Thus, for example, human patients may be treated with a peptide vaccine containing a human or a mouse CD20-fragment. There is evidence that strong immune responses can be elicited against xenogeneic proteins. Naftzger et al., *Proc. Natl. Acad. Sci. (USA)* 93: 14809-14814 (1996); International Patent Application PCT/US97/22669, filed December 10 1997, incorporated herein by reference. A suitable fragment is the 44 amino acid peptide spanning amino acids 136 to 179 of the sequence of mouse or human CD20. (Seq. ID Nos. 1 and 2) Other immunogenic fragments derived from the extracellular domain of CD20, or the entire CD20 molecule may also be used. Seq. ID. Nos. 3 and 4 shows the nucleic acid and amino acid sequences, respectively, of exon VI (the extracellular domain) of human CD20 as reported by Tedder et al., *J. Immunol.* 142: 2560-2568 (1989).

As used in the specification and claims hereof, an "immunogenic fragment" is a molecule which includes at least a portion of the extracellular domain of a transmembrane protein to direct and immunological response to that transmembrane protein when the immunogenic fragment is coupled to or administered with an antigenic carrier protein effective to break tolerance and administered with an adjuvant. It is not required that the immunogenic fragment alone be effective to stimulate an immune response, although such stimulation would not take a given fragment outside the scope of the present invention.

A preferred antigenic carrier protein is keyhole limpet hemocyanin which can be coupled to peptides using techniques described in Pierce Catalog Protocol. Other antigenic carrier proteins which can be used to break tolerance might be used in the invention include immunoglobulins, tuberculin, tetanus toxin and others well known in the art.

5 The peptide antigen containing the CD20 component and the antigenic carrier protein is formulated with a pharmaceutically acceptable adjuvant in a liquid carrier and administered to a patient suffering from NHL or another B cell disease. The composition will generally be administered by injection, for example, intramuscular, subcutaneous or intradermal injection, but might also be administered by way of a DNA vaccine (See US
10 Patent No. 5,580,859, incorporated herein by reference) or a viral vaccine, or after mixing with antigen presenting cells (APC's) such as dendritic cells, *ex vivo*. Alternatively, the antigen may be administered without adjuvant by injection into a host prepared by prior or simultaneous injection of an immune adjuvant. Specific amounts to be administered to a patient can be determined by monitoring the titer of anti-CD20 antibodies developed by the
15 patient, or by an average group of patients using well-known technology.

 When a peptide of the extracellular domain of human or mouse CD20 is coupled to KLH and administered with an adjuvant to mice, antibodies which react with CD20 are found in plasma. (Figs. 1A and B) These antibodies bind to Raji cells, a human lymphoma cell line, indicating the ability to bind to a cell expressing CD20. (Figs. 2A and
20 B). Moreover, the number of CD19⁺ B cells present in mice injected with either of the two CD20-KLH conjugates declines substantially (~30% decrease relative to controls). (Figs. 3 and 9). The assay used to quantitate B cell depletion detects CD19 which is also expressed on immature B cells that are CD20⁻. Thus, the 30% depletion actually underestimates the efficacy of the vaccine against CD20⁺ B cells.

25 Antibodies generated in mice after vaccination with human or mouse-derived CD20 fragments are specific for the peptides used, yet are capable of inducing immunity to the corresponding peptide from other species (Figs. 6A-D). Studies showed that in most instances the peptide, carrier protein and adjuvant are all needed for optimal response, although some responses were detected using less than all of the components. (Figs. 7A-D).

Several different adjuvants were also tested, and QS21 was found to be the most effective of those tested. (Fig. 8A-D).

While not intending to be bound by any particular mechanism, it is believed that the vaccines of the present invention are effective via at least two pathways. First, the generation of a humoral immune response to CD20 is effective to some extent to reduce the numbers of B cells bearing CD20 antigen in a manner consistent with normal immunological response to a target antigen. In addition, however, because CD20 has a signaling function, the binding of antibody to the CD20 moiety activates this signaling function to trigger apoptotic cell death. Such stimulation of apoptosis has been demonstrated to occur *in vitro* following passive treatments with a chimeric anti-CD20 antibody. Maloney et al., *Blood* 88 (Supp. 1): 637a (1996).

It is also possible that T cell mediated effector mechanisms are involved in the immune response. As evidence of this, we illustrate in Table 1 the mouse and human peptide sequences capable of binding to the corresponding mouse and human histocompatibility antigens. This information was derived from a search of the NIH Bioinformatics and Molecular Analysis Section HLA Binding Predictions database using the mouse and human CD20 amino acid sequences. (Parker et al., *J. Immunol.* 152: 163 (1994)).

While the method of the invention is illustrated here using CD20 or CD20-derived peptides as the antigen to target B cells, the invention is not limited to this embodiment. Rather, the inventions encompasses the use of vaccine compositions comprising an immunogenic portions of the extracellular domain of transmembrane protein or peptide, particularly a transmembrane protein or peptide having signaling function, coupled to or administered with an antigenic protein and/or adjuvant to break tolerance.

A non-limiting example of another transmembrane protein which can be used in whole or in part in the method of the invention is Her-2/neu. The Her-2/neu oncogene is a receptor-like tyrosine kinase that is expressed on the cell surface of a significant portion of solid tumors. It has been shown that patients with early stage breast cancer have a high titer of antibodies to Her-2/neu. Disis et al., *J. Clin. Oncol.* 15: 3363-3367 (19967). The amino acid sequence and domain structure of human Her-2/neu are shown in Seq. OD. No. 5 and Fig. 4, and isolation and expression of the extracellular domain has been disclosed.

International Patent Publication No. WO 90/14357, which is incorporated herein by reference. There is clinical data showing efficacy of monoclonal antibodies against Her-2-neu in the treatment of patients with Her-2/neu⁺ tumors, and potential synergism with chemotherapy. Thus, in accordance with the present invention, a vaccine composition comprising at least an immunogenic portion of the extracellular domain of Her-2-neu (amino acids 22 to 652) coupled to or administered with an antigenic protein or peptide such a KLH can be used as a vaccine to provide the same therapeutic benefits using an active as opposed to a passive approach.

A further non-limiting example of a transmembrane protein which can be used in whole or in part in the method of the invention is epidermal growth factor receptor (EGFR). The amino acid sequence and domain structure of human EGFR are shown in Seq. ID. No. 6 and Fig. 5. There is significant data showing that antibodies to EGFR can have anti-tumor activity in breast and prostate cancer, as well as several head and neck tumors. Prewett et al., *J. Immunother. Emphasis Tumor Humoral* 19: 419-27 (1996). The mechanism by which antibody therapy against EGFR may be efficacious can be through the ability to down-regulate vascular endothelial growth factor production by tumor cells and thereby decrease angiogenesis. Petit et al., *Am. J. Pathol.* 151: 1523-30 (1997). In accordance with the present invention, a vaccine composition comprising at least an immunogenic portion of the extracellular domain of EGFR (amino acids 25 to 645) coupled to or administered with an antigenic protein or peptide such a KLH can be used as a vaccine to provide the same therapeutic benefits using an active as opposed to a passive approach. Preferred immunogenic peptides would be selected from regions not deleted in the various types of truncated EGFR mutants associated with some cancers.

A further non-limiting example of a transmembrane protein which can be used in whole or in part in the method of the invention is VEGF receptor. There are significant data showing that antibodies to VEGF receptor can inhibit angiogenesis and thereby halt tumor progression. In accordance with the present invention, a vaccine composition comprising at least an immunogenic portion of the extracellular domain of VEGF receptor coupled to or administered with an antigenic protein or peptide such a KLH can be used as a

vaccine to provide the same therapeutic benefits using an active as opposed to a passive approach.

Still a further non-limiting example of a transmembrane protein which can be used in whole or in part in the method of the invention is the IL-2 receptor. The IL-2
5 receptor is expressed on most T-cells malignancies, and there is a data showing that antibodies to the IL-2 receptor can be used in the treatment of T-cell malignancies and autoimmune disorders. In the present invention, a composition is made comprising at least an immunogenic portion of the extracellular domain of the IL-2 receptor (e.g., P55 or P75),
coupled to or administered with an antigenic carrier protein or peptide such as KLH. and
10 used as a vaccine.

The vaccine compositions of invention can be used alone or in combination (concurrently or sequentially) with drugs or chemotherapy agents that provide therapeutic benefit for the condition being treated. In the case of NHL, suitable chemotherapy agents which can be used in combination with the CD20 based vaccine include alkylating agents,
15 anthrocyclines, cis-platinum, fludarabine, corticosteroids and vinca alkaloids. These same chemotherapy agents which might be used in combination with other vaccine compositions for other forms of cancer.

EXAMPLE 1

20 44 amino acid fragments of the extracellular domains of humans and murine CD20 (amino acids 136-179, Seq. ID Nos. 1 and 2) were synthesized using a solid-phase FMOC peptide synthesizer and coupled to KLH using the methodology described in the Pierce Catalog Protocol. The peptide coupled to KLH was then prepared for injection by formulation with QS-21 adjuvant. Balb/c mice were injected according to one of the
25 following protocols on days 1, 8, 15, 22 and 50 of the experiment:

- A. Murine CD20 fragment-KLH with QS-21 adjuvant
- B. Human CD20 fragment-KLH with QS-21 adjuvant
- C. KLH with QS-21 adjuvant
- 30 D. QS-21 adjuvant

- E. P190 (irrelevant protein) coupled to KLH with QS-21 adjuvant
- F. B3A2 (irrelevant peptide) coupled to KLH with QS-21 adjuvant.

The animals were sacrificed on day 62 of the experiment.

5 Serum samples from the mice were diluted 1:200 and evaluated by BSA-blocked ELISA using goat-anti-mouse antibody conjugated to alkaline phosphatase for antibodies which bind to human CD20, mouse CD20 and KLH. As shown in Figs 1A and B, mice injected with human CD20 coupled to KLH (Fig. 1A) or mouse CD20 coupled to KLH (Fig. 1B) administration of xenogeneic antibody produced a significant polyclonal antibody
10 response to both human and mouse CD20, while the response following administration of syngeneic antibody was principally limited to antibodies to the syngeneic form of CD20. Either xenogeneic or syngeneic peptide can therefore be used to generate an immune response.

 To confirm the ability of the antibodies to bind to B cells, Raji cells (a form of
15 human B-cell lymphoma that expresses CD20 on its surface) were blocked with human IgG, washed and then incubated for 30 minutes on ice with a 1:10 dilution of plasma from a mouse vaccinated with P-190-KLH control or huCD20-KLH. As a positive control, Raji cells were incubated with B1 antibody, or IgG2 as an isotypic negative control. After washing, the cells were incubated with goat-anti-mouse antibody, washed and fixed with 1% paraformaldehyde.
20 Flow cytometry analysis was performed in a Becton-Dickinson FACScan. The results are shown in Figs 2A and 3B, wherein the shaded data set are the experimental data set and the outlined data set is the negative controls. As is apparent, there is a strong binding of mouse antibodies and Raji cells, comparable to that observed with B1 antibody.

25

EXAMPLE 2

 To assess the number of B cells present in vaccinated mice, an evaluation was made of cells expressing CD19, a standard phenotypic marker for B cells. Spleens were harvested from the animals vaccinated in Example 1 and put into a single-cell suspension. After counting the total number of cells, the cells were stained with FITC-labeled anti-mouse
30 CD19 and the samples were analyzed by flow cytometry with a FACScan. 10,000 events

were collected. The percentage of CD19 positive cells minus the control gate was multiplied by the total number of cells to determine the number of CD19 positive cells in mice treated with the mouse and human CD20 peptide conjugates, and the P190 irrelevant peptide conjugate control.

5 As shown in Fig. 3, the absolute number of CD19 positive cells was significantly reduced in mice treated with either of the CD20 peptide conjugates. The level of CD19 positive cells is a reflection of the number of CD20 positive B cells, and the number of immature CD19⁺, CD20⁻ B cells in the samples. The absolute number of CD19⁺ B cells actually underestimates the therapeutic efficacy of the treatment for elimination of CD20⁺ B
10 cells, however, since CD19 is expressed on B cell progenitor cells before expression of CD20.

EXAMPLE 3

15 Mice were injected five times over two months with one of four treatment protocols as follows:

 human CD20 (44 aa fragment)-KLH plus QS1

 human CD20 (44 aa fragment)-KLH

 human CD20 (44 aa fragment) plus QS21

 KLH plus QS21

20 Blood was collected on week 9 for analysis by ELISA. Sera from the vaccinated mice were diluted 1:200 and incubated on BSA blocked plates coated with msCD20, huCD20, P190 or KLH. Secondary goat anti-mouse antibody conjugated to alkaline phosphatase was added, and the color change of p-nitrophenyl phosphate substrate was measured at 405 nm. The results are summarized in Figs. 7A-D. In most instances the peptide, carrier protein and
25 adjuvant are all needed for optimal response, although some responses were detected using less than all of the components.

EXAMPLE 4

30 Mice were vaccinated according to the schedule of Example 3 using one of four treatment protocols: human CD20 (44 aa fragment)-KLH plus QS21 adjuvant, mouse

CD20 (44 amino acid fragment)-KLH plus QS21, P190 (irrelevant protein)-KLH +QS21 and KLH and QS21 alone. Mouse serum samples were evaluated by ELISA for the presence of antibodies reactive with msCD20, huCD20, P190 and KLH. The results are shown in Figs. 6A-D. Antibodies generated in mice after vaccination with human or mouse-derived CD20 fragments are specific for the peptides used, yet are capable of inducing immunity to the corresponding peptide from other species.

EXAMPLE 5

Mice were vaccinated five times over two months with huCD20 fragment-KLH conjugate with no adjuvant or in combination with one of three adjuvants: QS21, BCG or Alum. Serum samples from the vaccinated mice were tested by ELISA. The results are summarized in Figs. 8A-D. QS21 was found to be the most effective of those tested.

EXAMPLE 6

To confirm the observations of Example 2, nucleated spleen cells were recovered by centrifugation in a density gradient from mice vaccinated with a CD20-KLH conjugate (human or mouse) in the presence of QS21 adjuvant. 1×10^6 cells from each mouse were incubated with $2 \mu\text{g}$ of rat anti-mouse CD19 FITC-labeled antibody or with isotope-matched FITC labeled rat antibody. Cells were washed, fixed and analyzed with a Becton Dickinson FACScaliber cytometer. Figs 9A-C, D-F and G-I show the results for three exemplary mice of each vaccination group. The decrease in the peak reflecting levels of CD19 positive spleen cells in each of the mice is apparent.

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Table 1

Species	Peptide Sequence	HLA Molecule	Score ($T_{1/2}$ of Dissociation of Molecule Containing this Subsequence)
human	NFIRaHTPYI	Kd	1600
human	FIRaHTPYI	Kd	48
human	FLKMeSLNF	A_0201	21.2
mouse	HFLKmRRLEL	Kd	1600
mouse	IYDCePSNSS	Kd	60
mouse	LIQTSKPYV	A_0201	89.4
mouse	ELIQSKPYV	A_0201	28.7

CLAIMS

- 1 1. A method for active vaccination against autologous cells expressing
2 transmembrane proteins comprising administering to a patient a vaccine composition
3 comprising at least an immunogenic portion of the extracellular domain of the
4 transmembrane protein, or a xenogeneic homolog thereof, coupled to or administered with an
5 carrier protein effective to break tolerance to the transmembrane protein and a
6 pharmaceutically acceptable adjuvant.
- 1 2. The method of claim 1, wherein the transmembrane protein is selected
2 from the group consisting of CD20, Her2-neu, VEGF receptor, epidermal growth factor
3 receptor, the CD19 molecule, interleukin-2-receptor, interleukin-4-receptor, and the P-
4 glycoprotein.
- 1 3. The method of claim 1, wherein the transmembrane protein is CD20.
- 1 4. The method of claim 1, wherein the vaccine composition comprises a
2 peptide having the sequence given by Seq. ID No 1 or 2.
- 1 5. The method claim 1, wherein the carrier protein is keyhole limpet
2 hemocyanin.
- 1 6. The method of claim 5, wherein the transmembrane protein is selected
2 from the group consisting of CD20, Her2-neu, VEGF receptor, epidermal growth factor
3 receptor, the CD19 molecule, interleukin-2-receptor, interleukin-4-receptor, and the P-
4 glycoprotein.
- 1 7. The method of claim 5, wherein the transmembrane protein is CD20.

1 8. The method of claim 7, wherein the vaccine composition comprises a
2 peptide having the sequence given by Seq. ID No 1 or 2.

1 9. A method for active vaccination against B cells expressing CD20
2 comprising administering to a patient a vaccine composition comprising at least an
3 immunogenic portion of the extracellular domain of CD20, or a xenogeneic homolog thereof,
4 coupled to or administered with an carrier protein effective to break tolerance to the
5 transmembrane protein and a pharmaceutically acceptable adjuvant.

1 10. The method claim 9, wherein the carrier protein is keyhole limpet
2 hemocyanin.

1 11. The method of claim 9, wherein the vaccine composition comprises a
2 peptide having the sequence given by Seq. ID No 1 or 2.

1 12. A method for treatment of B cell non-Hodgkin's lymphoma,
2 comprising administering to a patient suffering from B cell non-Hodgkin's lymphoma a
3 vaccine composition comprising at least an immunogenic portion of the extracellular domain
4 of CD20, or a xenogeneic homolog thereof, coupled to or administered with an carrier protein
5 effective to break tolerance to the transmembrane protein and a pharmaceutically acceptable
6 adjuvant.

1 13. A vaccine composition comprising at least an immunogenic portion of
2 the extracellular domain of the transmembrane protein, or a xenogeneic homolog thereof,
3 coupled to or administered with an carrier protein effective to break tolerance to the
4 transmembrane protein and a pharmaceutically acceptable adjuvant.

1 14. The composition of claim 13, wherein the transmembrane protein is
2 selected from the group consisting of CD20, Her2-neu, VEGF receptor, epidermal growth

- 15 -

3 factor receptor, the CD19 molecule, interleukin-2-receptor, interleukin-4-receptor, and the
4 P-glycoprotein.

1 15. The composition of claim 13, wherein the transmembrane protein is
2 CD20.

1 16. The composition of claim 15, wherein the vaccine composition
2 comprises a peptide having the sequence given by Seq. ID No 1 or 2.

1 17. The composition of claim 13, wherein the carrier protein is keyhole
2 limpet hemocyanin.

1 18. The composition of claim 17, wherein the transmembrane protein is
2 selected from the group consisting of CD20, Her2-neu, VEGF receptor, epidermal growth
3 factor receptor, the CD19 molecule, interleukin-2-receptor, interleukin-4-receptor, and the P-
4 glycoprotein.

1 19. The composition of claim 17, wherein the transmembrane protein is
2 CD20.

1 20. The composition of claim 19, wherein the vaccine composition
2 comprises a peptide having the sequence given by Seq. ID No 1 or 2.

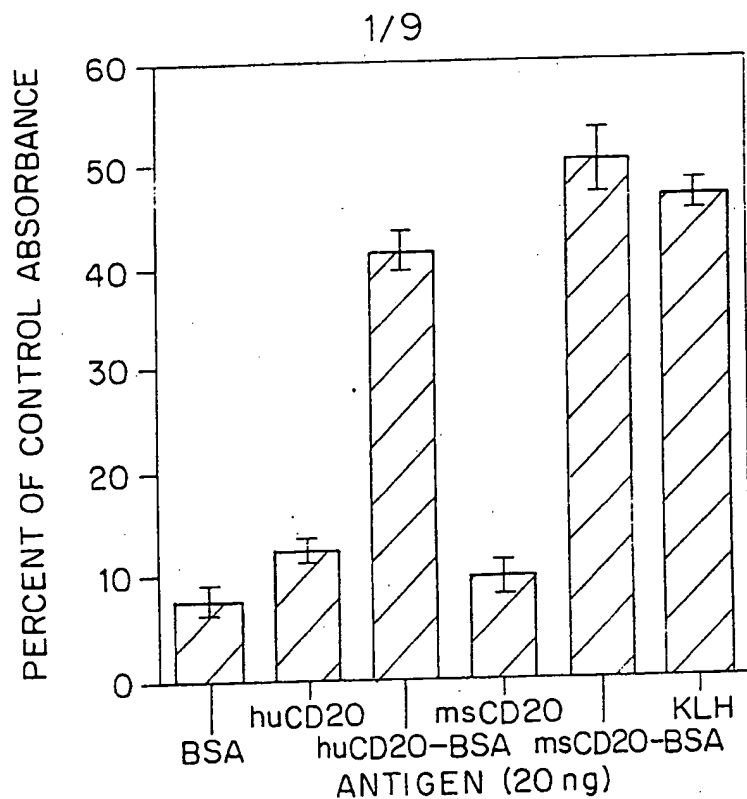


FIG. 1A

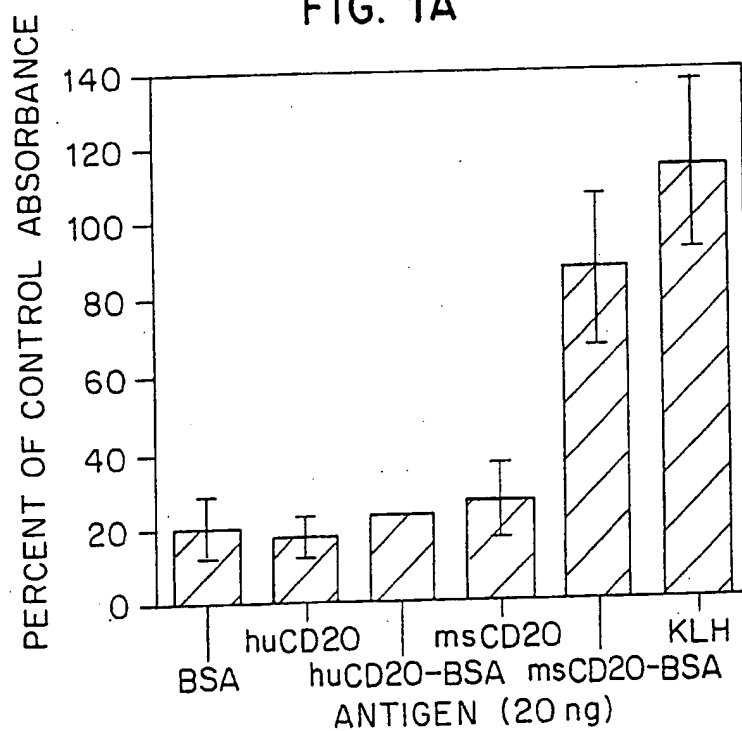
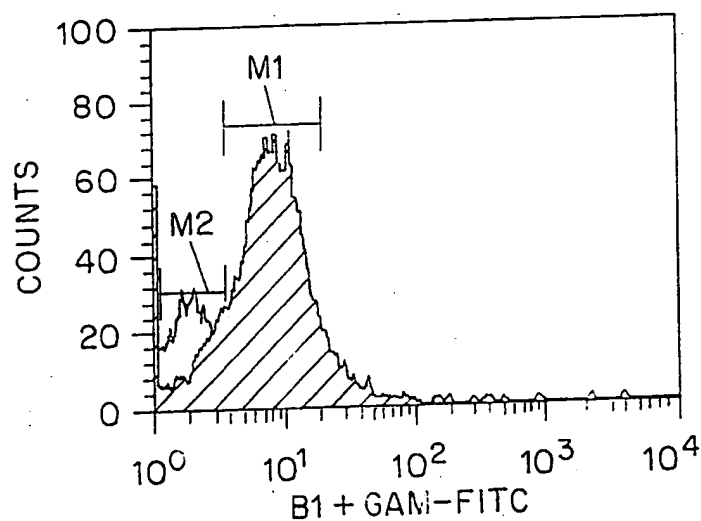


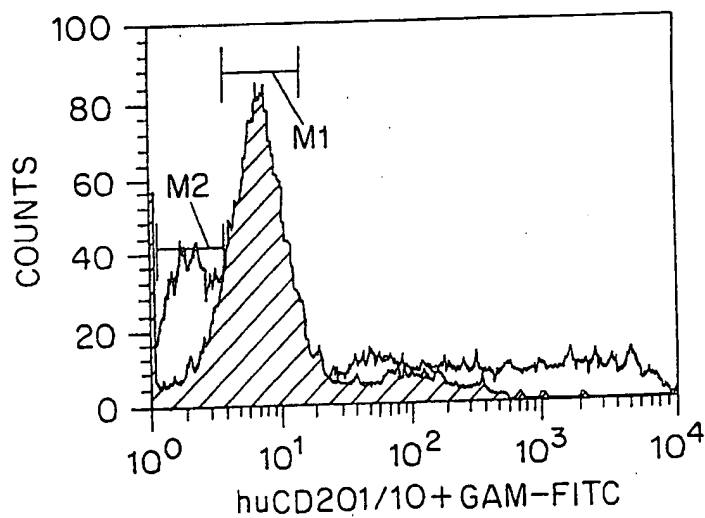
FIG. 1B



TOTAL EVENTS: 10000

MARKER	LEFT, RIGHT	EVENTS	% TOTAL
ALL	1, 9910	10000	100.00
M1	3, 17	7525	75.25
M2	1, 3	1201	12.01

FIG. 2A



TOTAL EVENTS: 10000

MARKER	LEFT, RIGHT	EVENTS	% TOTAL
ALL	1, 9910	10000	100.00
M1	3, 12	7327	73.27
M2	1, 4	1454	14.54

FIG. 2B

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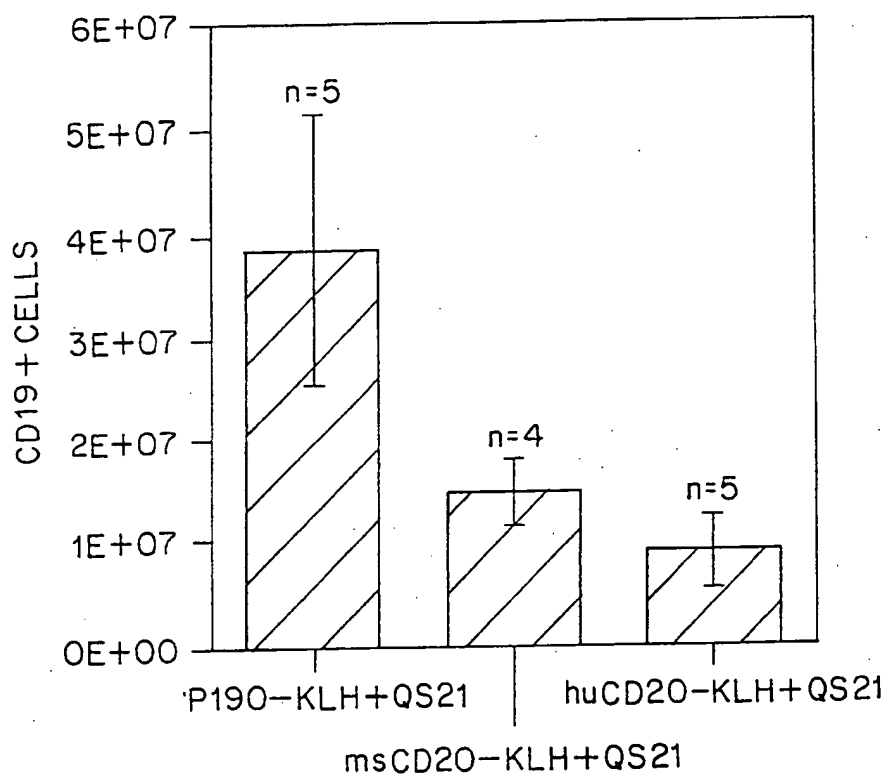


FIG. 3

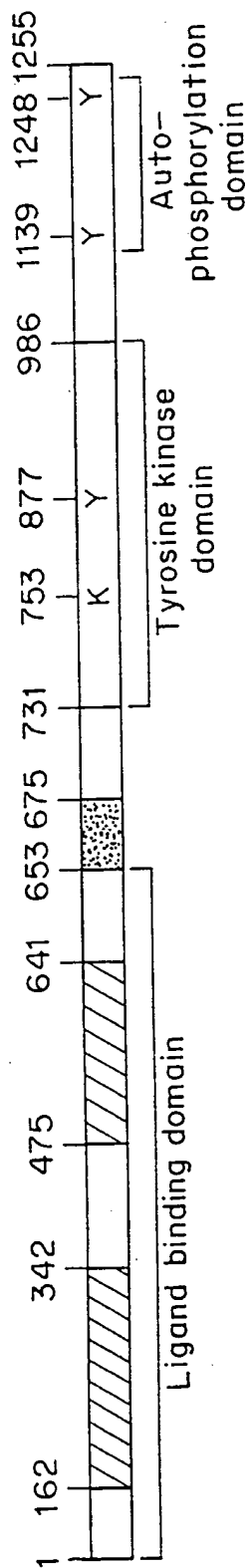


FIG. 4

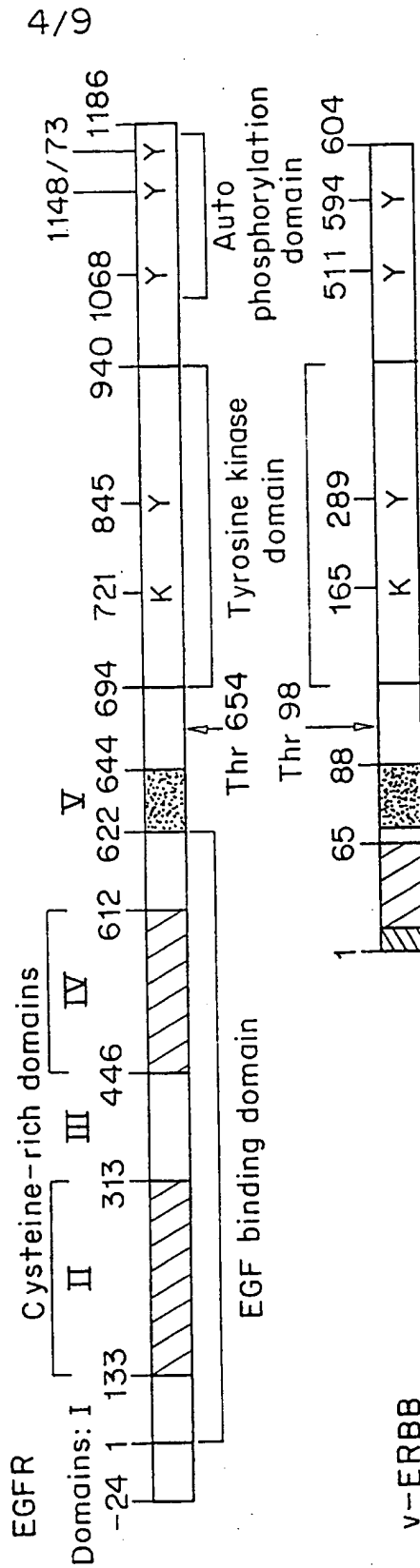


FIG. 5

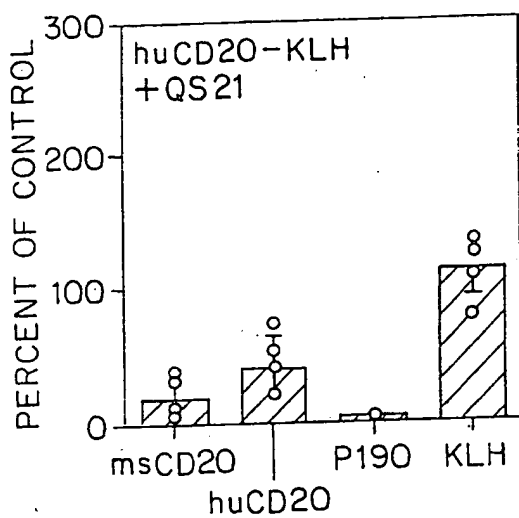


FIG. 6A

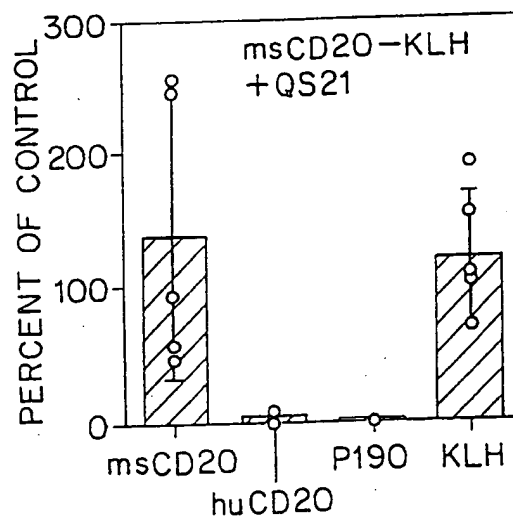


FIG. 6B

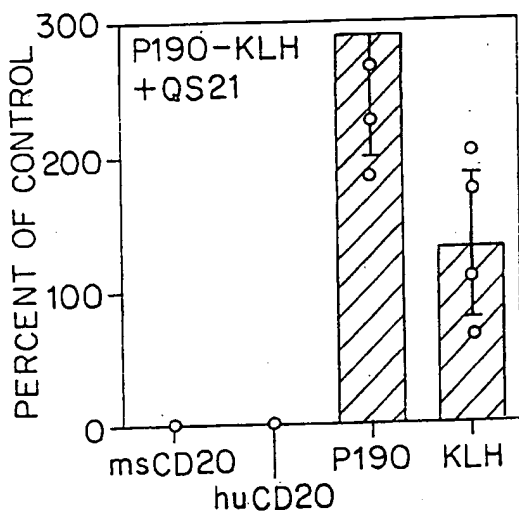


FIG. 6C

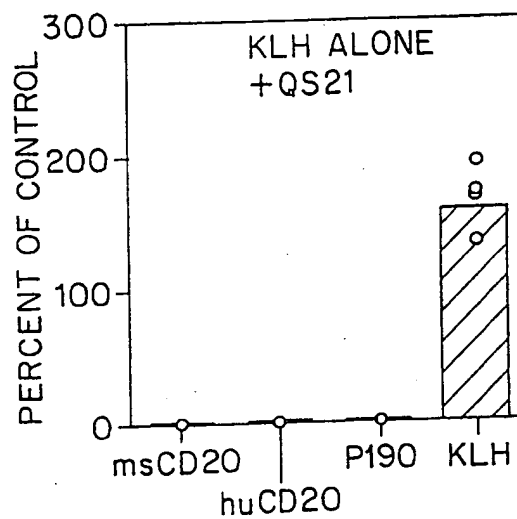


FIG. 6D

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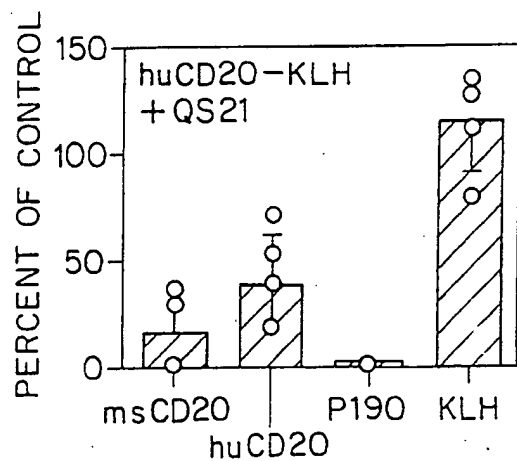


FIG. 7A

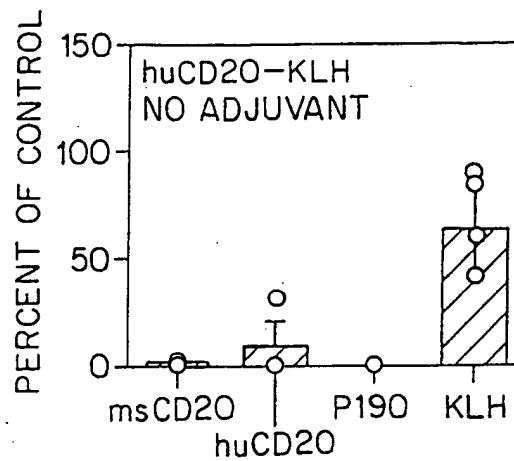


FIG. 7B

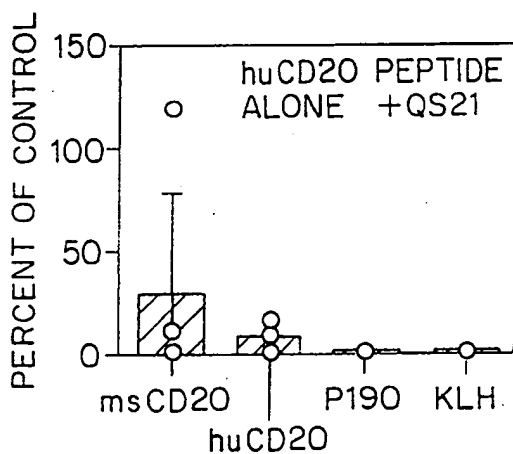


FIG. 7C

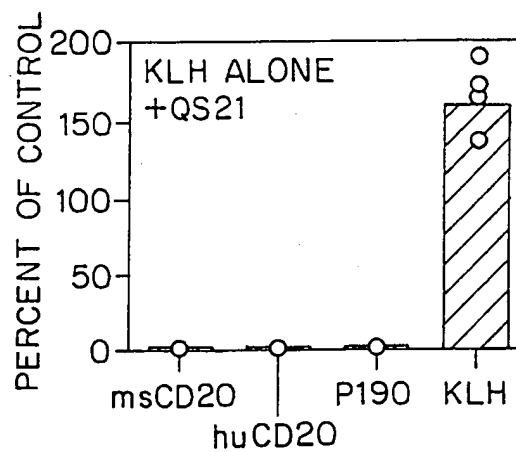


FIG. 7D

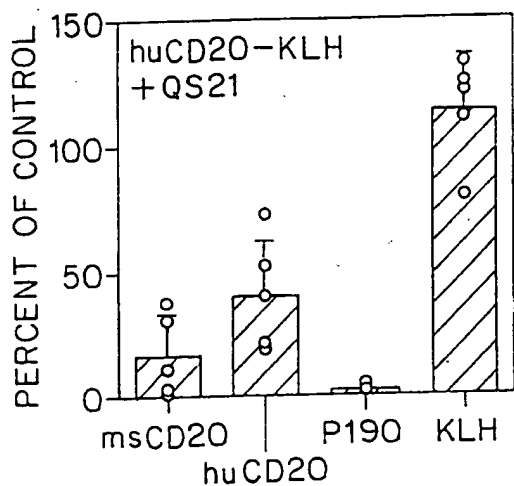


FIG. 8A

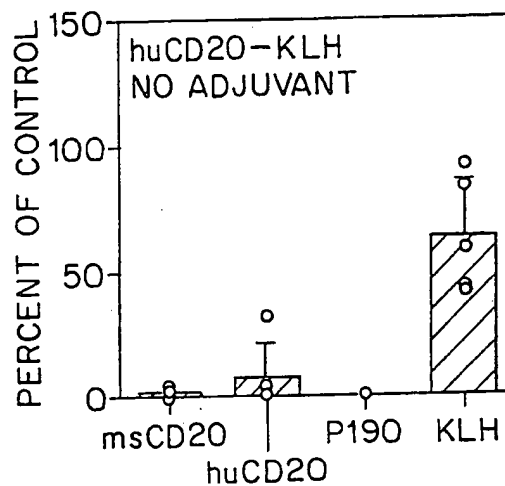


FIG. 8B

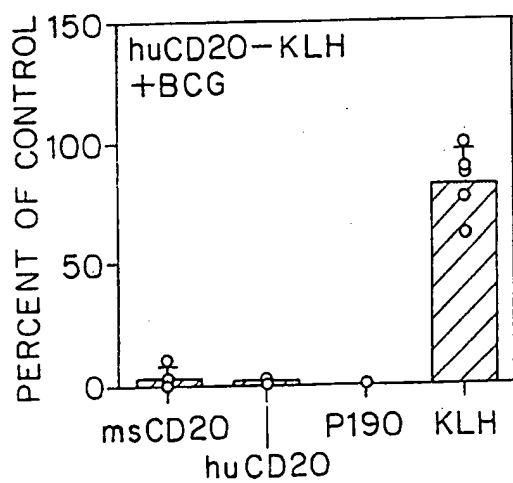


FIG. 8C

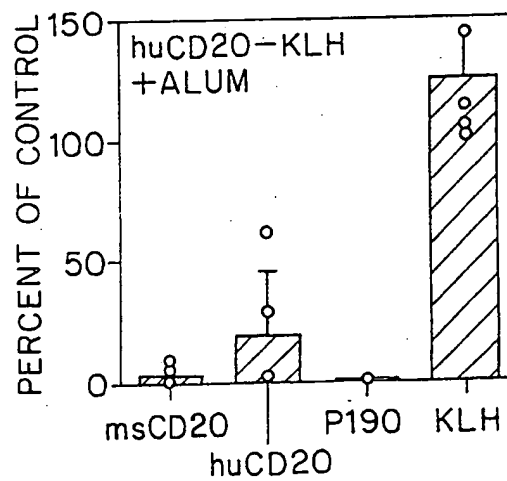


FIG. 8D

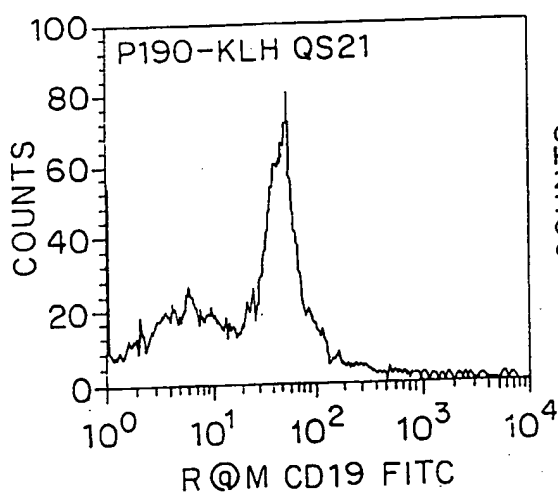


FIG. 9A

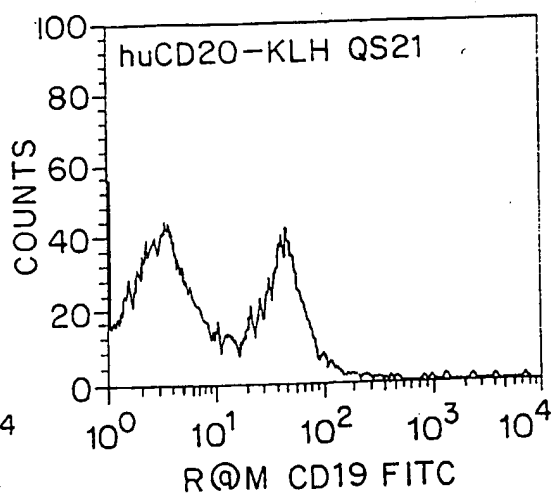


FIG. 9D

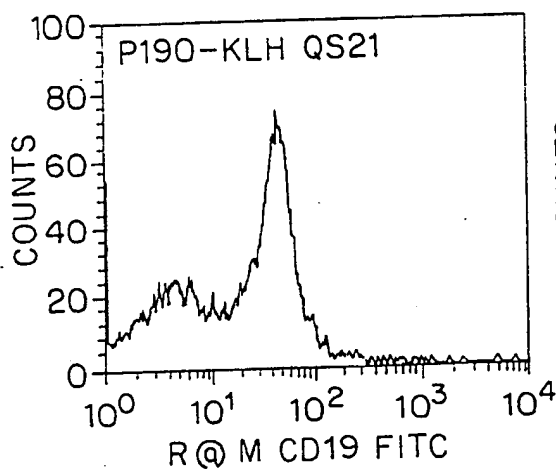


FIG. 9B

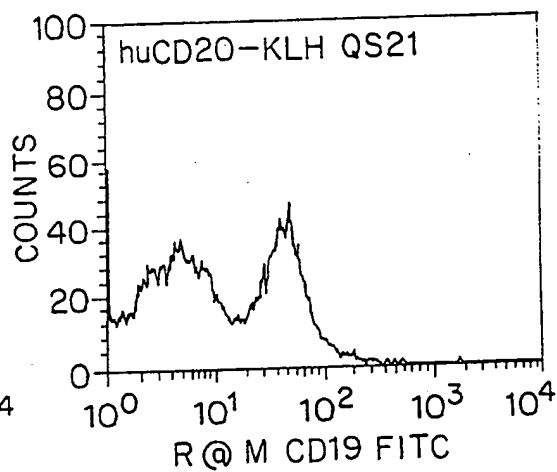


FIG. 9E

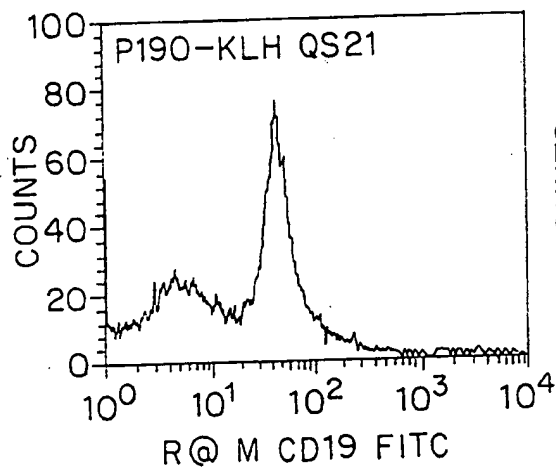


FIG. 9C

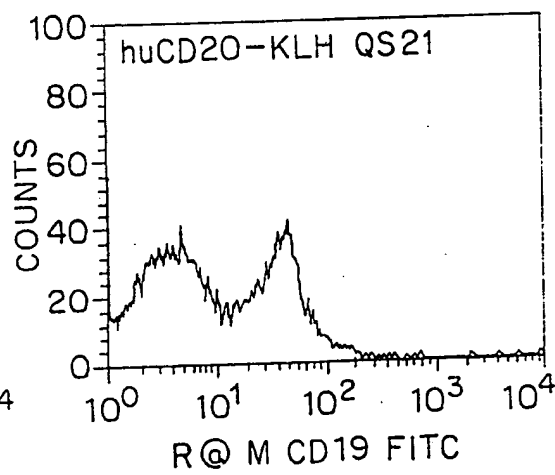


FIG. 9F

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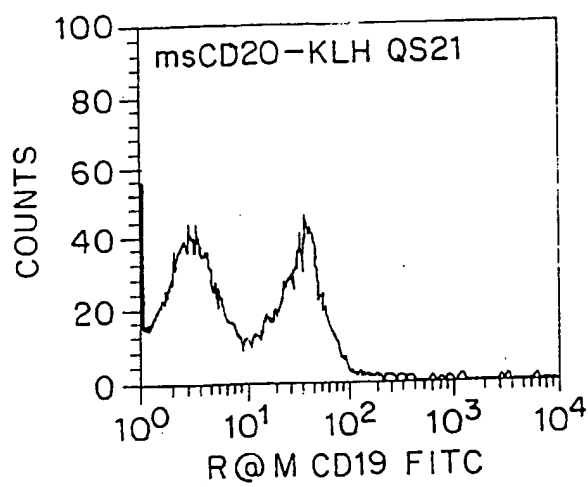


FIG. 9G

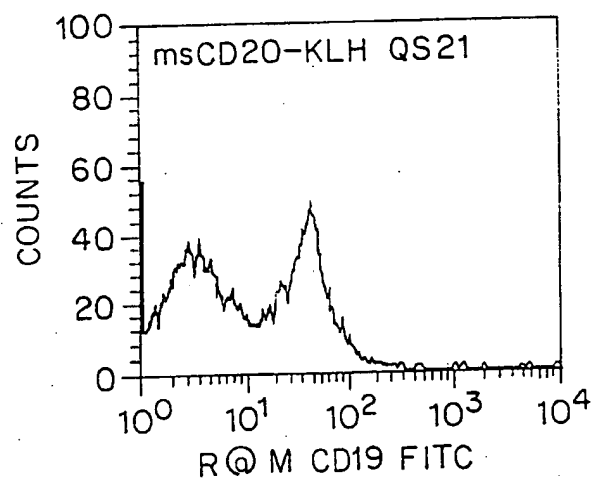


FIG. 9H

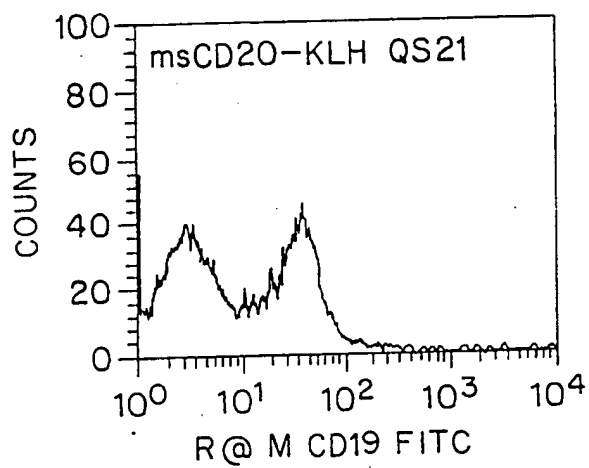


FIG. 9I

SEQUENCE LISTING

<110> Agus, David B.
 Scheinberg, David
 Zelenetz, Andrew D.
 Roberts, Wendy

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<151> 1998-05-08

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<170> PatentIn Ver. 2.0

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				20				25					30		

Glu	Lys	Asn	Ser	Pro	Ser	Thr	Gln	Tyr	Cys	Tyr	Ser
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<213> Murine

<220>

<223> murine CD20 fragment

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Glu Lys Asn Ser Pro Ser Thr Gln Tyr Cys Asn Ser
 35                      40

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    20                      25                      30
His Phe Leu Lys His Glu Ser Leu Asn Phe Ile Arg Ala His Thr Pro
    35                      40                      45
Tyr Ile Asn Ile Tyr Asn Cys Glu Pro Ala Asn Pro Ser Glu Lys Asn
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aattttatta gagctcacac accatatatt aacatataca actgtgaacc agctaattcc 180

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Leu Arg Leu Pro Ala Ser Pro Glu Thr His Leu Asp Met Leu Arg His
35 40 45

Leu Tyr Gln Gly Cys Gln Val Val Gln Gly Asn Leu Glu Leu Thr Tyr
50 55 60

Leu Pro Thr Asn Ala Ser Leu Ser Phe Leu Gln Asp Ile Gln Glu Val
65 70 75 80

Gln Gly Tyr Val Leu Ile Ala His Asn Gln Val Arg Gln Val Pro Leu
85 90 95

Gln Arg Leu Arg Ile Val Arg Gly Thr Gln Leu Phe Glu Asp Asn Tyr
100 105 110

Ala Leu Ala Val Leu Asp Asn Gly Asp Pro Leu Asn Asn Thr Thr Pro
115 120 125

Val Thr Gly Ala Ser Pro Gly Gly Leu Arg Glu Leu Gln Leu Arg Ser
130 135 140

Leu Thr Glu Ile Leu Lys Gly Gly Val Leu Ile Gln Arg Asn Pro Gln
145 150 155 160

Leu Cys Tyr Gln Asp Thr Ile Leu Trp Lys Asp Ile Phe His Lys Asn
165 170 175

Asn Gln Leu Ala Leu Thr Leu Ile Asp Thr Asn Arg Ser Arg Ala Cys
180 185 190

His Pro Cys Ser Pro Met Cys Lys Gly Ser Arg Cys Trp Gly Glu Ser

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Ala Arg Cys Lys Gly Pro Leu Pro Thr Asp Cys Cys His Glu Gln Cys 225 230 235 240		
Ala Ala Gly Cys Thr Gly Pro Lys His Ser Asp Cys Leu Ala Cys Leu 245 250 255		
His Phe Asn His Ser Gly Ile Cys Glu Leu His Cys Pro Ala Leu Val 260 265 270		
Thr Tyr Asn Thr Asp Thr Phe Glu Ser Met Pro Asn Pro Glu Gly Arg 275 280 285		
Tyr Thr Phe Gly Ala Ser Cys Val Thr Ala Cys Pro Tyr Asn Tyr Leu 290 295 300		
Ser Thr Asp Val Gly Ser Cys Thr Leu Val Cys Pro Leu His Asn Gln 305 310 315 320		
Glu Val Thr Ala Glu Asp Gly Thr Gln Arg Cys Glu Lys Cys Ser Lys 325 330 335		
Pro Cys Ala Arg Val Cys Tyr Gly Leu Gly Met Glu His Leu Arg Glu 340 345 350		
Val Arg Ala Val Thr Ser Ala Asn Ile Gln Glu Phe Ala Gly Cys Lys 355 360 365		
Lys Ile Phe Gly Ser Leu Ala Phe Leu Pro Glu Ser Phe Asp Gly Asp 370 375 380		
Pro Ala Ser Asn Thr Ala Pro Leu Gln Pro Glu Gln Leu Gln Val Phe 385 390 395 400		
Glu Thr Leu Glu Glu Ile Thr Gly Tyr Leu Tyr Ile Ser Ala Trp Pro 405 410 415		
Asp Ser Leu Pro Asp Leu Ser Val Phe Gln Asn Leu Gln Val Ile Arg 420 425 430		
Gly Arg Ile Leu His Asn Gly Ala Tyr Ser Leu Thr Leu Gln Gly Leu 435 440 445		
Gly Ile Ser Trp Leu Gly Leu Arg Ser Leu Arg Glu Leu Gly Ser Gly		

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 Pro Trp Asp Gln Leu Phe Arg Asn Pro His Gln Ala Leu Leu His Thr
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 500 505 510
 Gln Leu Cys Ala Arg Gly His Cys Trp Gly Pro Gly Pro Thr Gln Cys
 515 520 525
 Val Asn Cys Ser Gln Phe Leu Arg Gly Gln Glu Cys Val Glu Glu Cys
 530 535 540
 Arg Val Leu Gln Gly Leu Pro Arg Glu Tyr Val Asn Ala Arg His Cys
 545 550 555 560
 Leu Pro Cys His Pro Glu Cys Gln Pro Gln Asn Gly Ser Val Thr Cys
 565 570 575
 Phe Gly Pro Glu Ala Asp Gln Cys Val Ala Cys Ala His Tyr Lys Asp
 580 585 590
 Pro Pro Phe Cys Val Ala Arg Cys Pro Ser Gly Val Lys Pro Asp Leu
 595 600 605
 Ser Tyr Met Pro Ile Trp Lys Phe Pro Asp Glu Glu Gly Ala Cys Gln
 610 615 620
 Pro Cys Pro Ile Asn Cys Thr His Ser Cys Val Asp Leu Asp Asp Lys
 625 630 635 640
 Gly Cys Pro Ala Glu Gln Arg Ala Ser Pro Leu Thr Ser Ile Ile Ser
 645 650 655
 Ala Val Val Gly Ile Leu Leu Val Val Val Leu Gly Val Val Phe Gly
 660 665 670
 Ile Leu Ile Lys Arg Arg Gln Gln Lys Ile Arg Lys Tyr Thr Met Arg
 675 680 685
 Arg Leu Leu Gln Glu Thr Glu Leu Val Glu Pro Leu Thr Pro Ser Gly
 690 695 700
 Ala Met Pro Asn Gln Ala Gln Met Arg Ile Leu Lys Glu Thr Glu Leu

705	710	715	720
Arg Lys Val Lys Val Leu Gly Ser Gly Ala Phe Gly Thr Val Tyr Lys 725 730 735			
Gly Ile Trp Ile Pro Asp Gly Glu Asn Val Lys Ile Pro Val Ala Ile 740 745 750			
Lys Val Leu Arg Glu Asn Thr Ser Pro Lys Ala Asn Lys Glu Ile Leu 755 760 765			
Asp Glu Ala Tyr Val Met Ala Gly Val Gly Ser Pro Tyr Val Ser Arg 770 775 780			
Leu Leu Gly Ile Cys Leu Thr Ser Thr Val Gln Leu Val Thr Gln Leu 785 790 795 800			
Met Pro Tyr Gly Cys Leu Leu Asp His Val Arg Glu Asn Arg Gly Arg 805 810 815			
Leu Gly Ser Gln Asp Leu Leu Asn Trp Cys Met Gln Ile Ala Lys Gly 820 825 830			
Met Ser Tyr Leu Glu Asp Val Arg Leu Val His Arg Asp Leu Ala Ala 835 840 845			
Arg Asn Val Leu Val Lys Ser Pro Asn His Val Lys Ile Thr Asp Phe 850 855 860			
Gly Leu Ala Arg Leu Leu Asp Ile Asp Glu Thr Glu Tyr His Ala Asp 865 870 875 880			
Gly Gly Lys Val Pro Ile Lys Trp Met Ala Leu Glu Ser Ile Leu Arg 885 890 895			
Arg Arg Phe Thr His Gln Ser Asp Val Trp Ser Tyr Gly Val Thr Val 900 905 910			
Trp Glu Leu Met Thr Phe Gly Ala Lys Pro Tyr Asp Gly Ile Pro Ala 915 920 925			
Arg Glu Ile Pro Asp Leu Leu Glu Lys Gly Glu Arg Leu Pro Gln Pro 930 935 940			
Pro Ile Cys Thr Ile Asp Val Tyr Met Ile Met Val Lys Cys Trp Met 945 950 955 960			
Ile Asp Ser Glu Cys Arg Pro Arg Phe Arg Glu Leu Val Ser Glu Phe			

965 970 975
 Ser Arg Met Ala Arg Asp Pro Gln Arg Phe Val Val Ile Gln Asn Glu
 980 985 990
 Asp Leu Gly Pro Ala Ser Pro Leu Asp Ser Thr Phe Tyr Arg Ser Leu
 995 1000 1005
 Leu Glu Asp Asp Asp Met Gly Asp Leu Val Asp Ala Glu Glu Tyr Leu
 1010 1015 1020
 Val Pro Gln Gln Gly Phe Phe Cys Pro Asp Pro Ala Pro Gly Ala Gly
 1025 1030 1035 1040
 Gly Met Val His His Arg His Arg Ser Ser Ser Thr Arg Ser Gly Gly
 1045 1050 1055
 Gly Asp Leu Thr Leu Gly Leu Glu Pro Ser Glu Glu Glu Ala Pro Arg
 1060 1065 1070
 Ser Pro Leu Ala Pro Ser Glu Gly Ala Gly Ser Asp Val Phe Asp Gly
 1075 1080 1085
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65 70 75 80

Thr Ile Gln Glu Val Ala Gly Tyr Val Leu Ile Ala Leu Asn Thr Val
85 90 95

Glu Arg Ile Pro Leu Glu Asn Leu Gln Ile Ile Arg Gly Asn Met Tyr
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Tyr Glu Asn Ser Tyr Ala Leu Ala Val Leu Ser Asn Tyr Asp Ala Asn
115 120 125

Lys Thr Gly Leu Lys Glu Leu Pro Met Arg Asn Leu Gln Glu Ile Leu
130 135 140

His Gly Ala Val Arg Phe Ser Asn Asn Pro Ala Leu Cys Asn Val Glu
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Ser Ile Gln Trp Arg Asp Ile Val Ser Ser Asp Phe Leu Ser Asn Met
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 Ser Met Asp Phe Gln Asn His Leu Gly Ser Cys Gln Lys Cys Asp Pro
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 Thr Gly Pro Arg Glu Ser Asp Cys Leu Val Cys Arg Lys Phe Arg Asp
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 305 310 315 320
 Asp Gly Val Arg Lys Cys Lys Lys Cys Glu Gly Pro Cys Arg Lys Val
 325 330 335
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 355 360 365
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 Pro Pro Leu Asp Pro Gln Glu Leu Asp Ile Leu Lys Thr Val Lys Glu
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 Lys Thr Cys Pro Ala Gly Val Met Gly Glu Asn Asn Thr Leu Val Trp
 595 600 605
 Lys Tyr Ala Asp Ala Gly His Val Cys His Leu Cys His Pro Asn Cys
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 Thr Tyr Gly Cys Thr Gly Pro Gly Leu Glu Gly Cys Pro Thr Asn Gly
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 690 695 700

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Gly Ala Phe Gly Thr Val Tyr Lys Gly Leu Trp Ile Pro Glu Gly Glu
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Gln His Val Lys Ile Thr Asp Phe Gly Leu Ala Lys Leu Leu Gly Ala
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Glu Glu Lys Glu Tyr His Ala Glu Gly Gly Lys Val Pro Ile Lys Trp
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 1205 1210

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/10065

A. CLASSIFICATION OF SUBJECT MATTER IPC(6) : A01N 37/18 US CL : 514/2, 12 According to International Patent Classification (IPC) or to both national classification and IPC																				
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) U.S. : 514/2, 12 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) Please See Extra Sheet.																				
C. DOCUMENTS CONSIDERED TO BE RELEVANT																				
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.																		
X	Database BIOSIS, AN 1997:22684, HOOJBERG et al. Lysis of Syngeneic Tumor B Cells by Autoreactive Cytotoxic T Lymphocytes Specific for a CD19 Antigen-Derived Synthetic Peptide. J. Immunoth. 1996, Vol. 19, No. 5, pages 346-356, see especially the Abstract.	1-11																		
X	US 5,550,214 A (EBERLEIN et al.) 27 August 1996, see especially cols 17-22.	1,2,5,6																		
X	US 5,726,023 A (CHEEVER et al.) 10 March 1998, see especially cols 3, 13, 14.	1,2,5,6																		
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.																				
<table border="0"> <tr> <td>* Special categories of cited documents:</td> <td>* I</td> <td>later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</td> </tr> <tr> <td>* A document defining the general state of the art which is not considered to be of particular relevance</td> <td>* X</td> <td>document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</td> </tr> <tr> <td>* B earlier document published on or after the international filing date</td> <td>* Y</td> <td>document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</td> </tr> <tr> <td>* L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</td> <td>* A</td> <td>document member of the same patent family</td> </tr> <tr> <td>* O document referring to an oral disclosure, use, exhibition or other means</td> <td></td> <td></td> </tr> <tr> <td>* P document published prior to the international filing date but later than the priority date claimed</td> <td></td> <td></td> </tr> </table>			* Special categories of cited documents:	* I	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention	* A document defining the general state of the art which is not considered to be of particular relevance	* X	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone	* B earlier document published on or after the international filing date	* Y	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art	* L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	* A	document member of the same patent family	* O document referring to an oral disclosure, use, exhibition or other means			* P document published prior to the international filing date but later than the priority date claimed		
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Date of the actual completion of the international search 10 AUGUST 1999		Date of mailing of the international search report 29 SEP 1999																		
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230		Authorized officer <i>Susan Ungar</i> SUSAN UNGAR Telephone No. (703) 308-0196																		

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/10065

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☒ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
1-11
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/10065

B. FIELDS SEARCHED

Electronic data bases consulted (Name of data base and where practicable terms used):

GENESEQ, SWISS-PROT, SPTREMBL, APS, EMBASE, BIOSIS, MEDLINE, CAPLUS, DRUGU, PROMT, SCISEARCH, CANCERLIT, LIFESCI, TOXLINE, PHIN
search terms: vaccin?, CD20, her2, neu, erbb2

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING

This ISA found multiple inventions as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Group I, claim(s) 1-11, drawn to a method for active vaccination against autologous cells expressing transmembrane proteins.

Group II, claim(s) 12 drawn to a method for treatment of B cell non-Hodgkin's lymphoma.

Group III, claim(s) 13-20, drawn to a vaccine composition.

The inventions listed as Groups I-III do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

The technical feature linking groups I-III appears to be that they all relate to a method for active vaccination with at least an immunogenic portion of the extracellular domain of a transmembrane protein.

However, Hooijberg et al (J. Immunother. Emphasis Tumor Immunol, 1996, 19(5), 346-356 specifically teaches a method of active immunization with at least an immunogenic portion of the extracellular domain of a transmembrane protein wherein that protein is CD19, wherein that protein is CD20 (see abstract).

Therefore, the technical feature linking the inventions of Groups I-III does not constitute a special technical feature as defined by PCT Rule 13.2, as it does not define a contribution over the prior art.

The special technical feature of Group I is considered to be a method for active vaccination.

The special technical feature of Group II is considered to be a method of treatment.

The special technical feature of Group III is considered to be a vaccine composition.

Accordingly Groups I-III are not so linked by the same or a corresponding special technical feature as to form a single general inventive concept.

This application contains claims directed to more than one species of the generic invention. These species are deemed to lack Unity of Invention because they are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for more than one species to be searched, the appropriate additional search fees must be paid. The species are as follows:

Group I

Claim 1 is generic to a plurality of distinct species which are transmembrane proteins that are different in structure and function wherein the transmembrane proteins are:

- Species A - CD20 (claims 2-11)
- Species B - Her2-neu (claims 2 and 6)
- Species C - VEGF Receptor (claims 2 and 6)
- Species D - epidermal growth factor receptor (claims 2 and 6)
- Species E - CD19 (claims 2 and 6)
- Species F - interleukin-2-receptor (claims 2 and 6)
- Species G - interleukin-4-receptor (claims 2 and 6)
- Species H - P-glycoprotein (claims 2 and 6)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/10065

Group III

Claim 13 is generic to a plurality of distinct species which are transmembrane proteins that are different in structure and function wherein the transmembrane proteins are:

- Species A - CD20 (claims 14-20)
- Species B - Her2-neu (claims 14 and 18)
- Species C - VEGF Receptor (claims 14 and 18)
- Species D - epidermal growth factor receptor (claims 14 and 18)
- Species E - CD19 ((claims 14 and 18)
- Species F - interleukin-2-receptor (claims 14 and 18)
- Species G - interleukin-4-receptor (claims 14 and 18)
- Species H - P-glycoprotein (claims 14 and 18)